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THE S.S. UNITED STATES — PAGE THREE
WSE MEETINGS — PAGE TWO

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No. 12



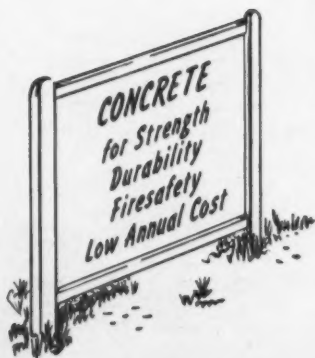
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HEADQUARTERS OF
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84 E. RANDOLPH STREET
CHICAGO 1, ILLINOIS
TELEPHONE: RA NDOLPH 6-1736

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Cover Story

The luxurious and speedy liner seen passing the Statue of Liberty in New York is the *S. S. United States*, the Queen of the seas and holder of the transatlantic speed record. For more information about this beauty, turn to page 3.

—United States Lines photo



May 20, Noon Luncheon Meeting

Speaker: A. J. Carlson, Ph.D., M.D., former Director, Department of Physiology, University of Chicago.

Subject: "Our Food and our Future."

Dr. Carlson will speak on the ever growing problem of population versus the supply of food. The population of the world is increasing year by year at an alarming rate and the question of feeding this population is a matter of grave concern. How will this problem be solved, or will it be solved? The speaker may be able to answer this question.

May 25, Annual Spring Dinner

Speaker: Virgil E. Gunlock, Commissioner of Public Works, City of Chicago.

Subject: "The Business of Building a Big City."

Place, Furniture Club of America; time, Fellowship—5:30, Dinner—7:00.

See page 6 for complete details.

August 15, Golf Tournament

Place, Chevy Chase Country Club, Wheeling, Illinois. See page 18 for complete details.

WSE's Dining Room

will be closed during June, July and August, due to the construction necessary for the Society's expansion program. The Dining Room will reopen early in September.

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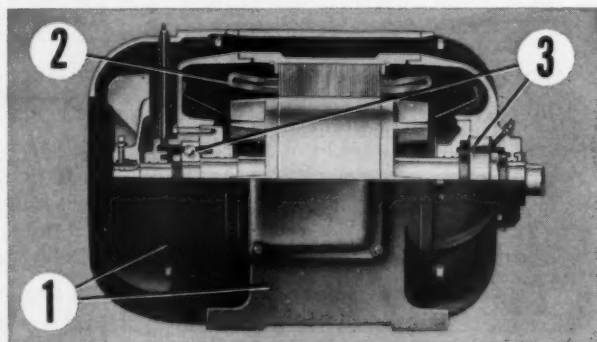


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The S.S. United States

By E. E. Benzenberg

It may be interesting to explain some of the background leading up to the decisions by the Government to build ships which have national defense features included in their basic design.

During, and after the termination of World War II, the Armed forces in this country learned several lessons in regard to the levels at which our Merchant Marine must be maintained if the United States is to be able successfully to maintain its own security and, at the same time, contain and defeat the aggressive actions of any potentially unfriendly nation in other parts of the world. The lesson pertinent to this discussion was that this country was sadly lacking in large, fast vessels capable of rapid conversion into troop transports. The few vessels which were available, including those loaned to us by our allies, were discovered to be lacking in vital defense features, and, because of their inherent design as passenger vessels, were also found to require costly and lengthy alterations before they could serve as transports at all. An examination of rentals paid to foreign vessels, including costs of conversion and reconversion, further showed that it was financially uneconomical to depend on the utilization of foreign-flag vessels under war conditions.

The foregoing, plus the possibility—even probability—that any future war might find friendly foreign nations unable to make available their own vessels for the transport of American soldiers to critical areas throughout the world, convinced the United States Navy and the Maritime Administration that in any future merchant construction consideration should, of necessity, be given to the addition of national defense features. In

making this decision it was recognized that the addition of such features would penalize the shipowners from the standpoint of initial construction costs. For that reason it was agreed that the Government, through the Maritime Administration, should contribute funds toward the construction of defense features in such vessels.

In March, 1946, the United States Lines decided that it would be advisable to build an additional large passenger vessel to supplement the service offered by the *S. S. AMERICA*, and Mr. W. F. Gibbs, head of the firm of Gibbs & Cox, Inc., was chosen as the designer. In preliminary meetings with Governmental agencies it was agreed that the vessel should be designed and constructed basically as a Naval auxiliary.

As such, high speed, safety, long range of operation, and rapid convertibility from a commercial vessel to a troop transport were of prime importance. Its commercial use as a passenger vessel was of secondary importance.

The design of a large transatlantic liner is by no means an easy task, since it is necessary to deal with a dozen or more Governmental agencies and regulatory bodies in addition to the owners. The *S.S. UNITED STATES* project was further complicated by the interjection of hard and fast requirements of the Maritime Administration, one of the first of which was that Gibbs & Cox initiate and maintain high standards of security throughout the development of the design, the construction, and

(Continued on Page 4)



—Photo courtesy United States Lines

A view of a sitting room of a suite aboard the *S. S. United States*

Mr. Benzenberg, Senior Coordinator, Hull Division, Gibbs and Cox, Inc., New York, N.Y., gave this talk on January 26, 1953, before the Western Society of Engineers at the Society's Headquarters in Chicago.

(Continued from Page 3)

ultimately the operation of the vessel.

Navy fire protection regulations prohibit the use of wood, and stipulate that all materials used must be fire-resistant. Had the *UNITED STATES* been designed for use exclusively by the Navy the problem would have been relatively simple. But since it had to be used as a passenger ship the designers were forced to carry on extensive investigations and tests in order to locate or develop materials meeting the Navy fire protection requirements, and which could, at the same time, satisfactorily replace non-fire resistant materials normally used in passenger vessels.

The U.S. Coast Guard is the controlling agency over commercial vessels, and its requirements for fire protection had, therefore, to be included in the design. Under their regulations, then in effect, passenger ships in this country could be built in conformity with either of two standards of fire protection. One, the lower standard, to which all American-flag ships are designed and built, exceeds the requirements of the 1929 International Convention of Safety of Life at Sea; the other, to which no merchant vessel had ever been built, sets much higher standards, as established by Senate Report 184. In order to meet the Navy requirements the decision was made to use the higher standard as established by Senate Report 184.

The Coast Guard suggested a double check on the tests that were the basis of the high standards set forth in Senate Report 184. For this purpose, the Coast Guard, with the active cooperation of Gibbs & Cox and a number of outside firms, constructed on the premises of the Bureau of Standards a typical three person stateroom, together with portions of adjoining rooms. Placed therein were all of the clothing and accessories that three persons would normally take on a transatlantic voyage. Since the purpose of the test was to determine the temperature rise in the room if a fire were to start accidentally, and entirely consume its contents, the clothing was purposely scattered to insure complete combustion. An abnormal condition was thus established, with the knowledge that a far less dangerous fire hazard would exist under normal conditions.

The results of this fire test solved many problems, the most important of

which was that all staterooms should be furnished with materials which would not propagate a flame. This justified the previously thought-out design details proposed by Gibbs & Cox in the use of fire resistant mattresses, drapery materials and upholstery, and, more important, in the elimination of the highly inflammable kapok type of life preservers. In order to carry out this program, the designer, in the interest of expedition, worked jointly with the Coast Guard in the development of specifications which could be used in determining whether or not fabrics and other materials could be classed as fire resistant and thus used on the vessel.

Since there was a very limited number of fabrics which could meet these specifications, it became necessary to resort to treating fabrics with a durable-type fire-retardant chemical. Although there were numerous chemicals on the market, all but two were hygroscopic, and could not be used aboard ship. Durability of treatment was essential in order to insure maintenance of the flame retardant properties even after repeated washings or dry cleanings. This treatment was successfully developed and applied, with the result that many fabrics which had previously been highly inflammable, such as cotton batting used in mattresses, and decorative fabrics, will not, aboard the *S. S. UNITED STATES*, sustain combustion. One of the outstanding results is the substitution in all life preservers of a non-inflammable glass fibre material for the previously used highly inflammable kapok.

One of the toughest problems was that of finding an oil paint that would contain a fire without the flame "flashing" on the bulkhead, as happened in the unfortunate fire aboard the *S. S. NORONIC* in Canada. Representatives of all of the leading paint companies were assembled and presented with a request that they do everything possible to work out a solution. All but one reported that they had been working on the problem for years with no success. One firm, however, developed a paint to which a flame, at a temperature of 2,300° could be applied, and then removed, without the fire continuing.

When it came to choosing the proper deck covering, bearing in mind the dual purpose of having a decorative as well as fire resistant covering, well over

100 different types were examined and tested.

The technical work was, of course, proceeding concurrently with all the investigating and testing of materials. The design of any large vessel, particularly one which will operate in the North Atlantic, is a difficult and complicated task. It represents the combined engineering efforts required in designing a cantilever-type bridge, a first-class hotel, and a public service power house, plus those required in designing a sturdy watertight hull capable of operating in waters where tremendous waves, ranging in length from 300 to 600 feet, are often encountered. Added to this is the requirement that the vessel remain upright and stable.

Inherent in the design work was the requirement that the beam and length be limited to permit its passage through the Panama Canal. Were it not for this limitation, the *S. S. UNITED STATES* might well have been the longest and largest vessel in the world.

In order to arrive at the best hull form, models were built and extensive tests carried out in tanks simulating the vessel's operation in varying sea conditions. Such tests also included model testing of the vessel in a wind tunnel to insure the best flow of air over the hull and superstructure in relation to the stack.

The structure of a vessel of this magnitude could not be judged by ordinary standards since allowances had to be made for the dynamic effects and severe rocking strains to which the vessel would be subjected. This had to be done with a minimum weight and a system of framing which would dispose the material to the best advantage.

In conjunction with this, the highest class materials had to be used. In order to minimize vibration, extra stiffness was required in the forward and after ends to resist the forces imposed on the vessel when running into heavy seas. The extensive use of welding aided in reducing weight and resulted in the construction of a vessel with its sides as smooth and slick as a private yacht's. The designers and builders of machinery have been advancing in the art of developing more powerful engines, yet the weight of such equipment has been—over a period of time—gradually reduced. Since the machinery was located at a low level, it became necessary to

reduce the topside weight radically. The use of aluminum helped reduce the topside weight, and had an added advantage since the lower modulus of elasticity of the material permitted the omission of expansion joints, which are always troublesome.

Riveting of the aluminum superstructure was necessary. These rivets, strange as it may seem, were stored in deep freeze units and driven cold, which is a radical departure from the method of driving red-hot rivets.

In order to meet Navy standards, and to reduce topside weight, all wooden deckings were eliminated from the weather, or exposed decks. A Neoprene Latex plastic decking was substituted. This, it might be added, is an innovation in a passenger ship, being the first time wooden decks have been completely eliminated in any passenger vessel.

Since the *UNITED STATES* was designed as a naval auxiliary, there was specified a standard of safety in regard to stability and sub-division that far exceeded our then-present minimum laws as well as the laws which have been recently enacted as a result of the International Conference of Safety of Life at Sea held in 1948.

As a further means of protecting the

passengers, the ship was provided with a Safety Room. This space, which is akin to the Damage Control Center on a Naval vessel, is the focus for safety features and in the event of an emergency the complete picture of the ship's condition can be seen at a glance and the necessary counter-measures taken and instructions given.

The arrangement of the ship was, in itself, a problem when one considers that there must be provided, for approximately 2,000 passengers and 1,000 crew members, all of the facilities available normally to them within their own home, towns and cities.

During the course of developing the arrangements, constant consideration had to be given to the ultimate use of the vessel as a troop transport. Its design as completed makes it possible, when converted, to carry from 12 to 14,000 troops—close to a full division.

The vessel has 26 public spaces, which, during operation as a passenger vessel, are useful only as passenger recreation and pleasure areas. These spaces, however, have been carefully designed and laid out for specific uses in the event conversion to a troopship becomes necessary.

Consistent with developing a modern design, air conditioning was provided

for all accommodations, crew and passenger alike. The design provided for individual control of temperature in each room. This was accomplished by a chilled water system, with a cooler serving a bank of rooms and with each room having its individual heater, usually located overhead behind a hinged panel in the bathroom.

In spite of the fact that the requirements for fire protection limited the choice of decorative materials, a pleasing decor has been created by the interior decorators, Smyth, Urquhart and Marckwald. It is definitely not gaudy and can be best described as typically American. The furniture, again in the interest of saving weight, is made entirely of aluminum and the upholstery used has been treated for fire resistance.

The propulsion machinery installation, representing the combined efforts of numerous designers, manufacturers and the shipbuilder, is the last word in very modern high pressure, high temperature machinery. It is so efficient that it permits the ship to attain high speeds while using even less fuel than is expended in other passenger vessels of comparable size at much lower speeds. This means that the *S. S. UNITED STATES*, as a troopship, could in a very short time deliver a division of troops to almost any port in the world and return to the United States, a round voyage of about 10,000 miles, without stopping for fuel, water or supplies.

In order to make the vessel self-sufficient in its operation, not only as a passenger vessel but particularly as a troop transport, distilling plants have been provided to furnish the purest type of water required for the operation of the boilers and for drinking purposes.

The electrical phase of the design was an unusually complex and important one, particularly because of the important role electric power plays in the operation of the ship, its safety, and in providing facilities for the comfort and convenience of the passengers.

Unlike a hotel the *S. S. UNITED STATES* cannot obtain electric power from a station miles away. It must generate its own power, and must maintain a service so reliable and flexible that there can be no failure even in the case of a shut-down of one or more of its generators, or of a circuit interruption to some of its feeders since no modern



—Photo courtesy United States Lines

A view of the First Class Cocktail Lounge aboard the *S. S. United States*

(Continued on Page 13)

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—Atomic Energy—

Its History and Development

By Andrew W. Kramer

Many of you, no doubt, have heard one of the several stories about Michael Faraday's discovery of the principle of the electric generator. It seems that some of the more practically minded gentlemen of the day wanted to know what it was good for.

"Well," Faraday is supposed to have said, "some day you may be able to tax it."

Last year the electric utility companies in this country paid over a billion dollars in taxes.

And that is why all of us should have an interest in Atomic Energy. We are already being taxed for it.

Since 1940 Congress has appropriated over 8 billion dollars for atomic energy in this country. Almost one and three quarters billion of these 8 billion dollars are being spent this fiscal year.

And you are paying for it.

More than that—it is estimated that 5 per cent of the total scientific and engineering population of the country is engaged in atomic energy work.

What Have We To Show?

Now, you may ask, in view of all this effort and this vast expenditure of money, what have we to show for it? Where do we stand with respect to realizing something on our investment.

Curiously enough, we stand to realize something on our investment, in one way we may not seem to have realized very much. We have exploded some 20 or 25 atomic bombs. We have produced a sizeable quantity of radioactive isotopes for use in medicine and industry, and, we have produced a few—probably a few hundred—kilowatthours of electricity, the latter only on an experimental basis. We have built no atomic power plants as such. Last week in Nevada, we blew up a frame house and only

partially destroyed another. This for about $6\frac{1}{2}$ billion dollars.

Don't be misled by this apparently poor showing, however. The picture is not as dark as it might seem. The main reason why we have no atomic power plants or atomic engines today is because it is hard to make atomic engines—very much harder, it seems, than to make atomic bombs. In fact atomic bombs are absurdly easy to make. All you need is to have two pieces of Uranium-235 or plutonium, one in each hand, and suddenly bring them together, as fast as you can. The only trouble with this method is, you would never know whether you succeeded, if you did.

It is *not only* difficult to make nuclear power plants but until quite recently, it was not completely clear to people connected with the effort *why we*—or anyone else—might really want to build nuclear power plants. After all, we do pretty well with our coal and oil-fired power plants, and we have plenty of those kinds of fuel. Most of the utility people talked against atomic power plants—they were sure such plants could not compete, on an economic basis, with conventional fuel-fired plants.

Briefly, it is taking a cold war to give motivation to the development of nuclear reactors for power, much in the same way that it took a hot war to give motivation and point to the development of the first atomic bomb.

Before discussing the details of some of the nuclear reactors, I would like to redirect your attention to the fundamental facts underlying nuclear fission, which explain on the one hand why reactors are hard to build and on the other hand why it is taking the pressure of a cold war to force on us the so-called peacetime benefits of atomic energy.

One of the simplest ways of explaining nuclear energy is to compare a nuclear fire with an ordinary chemical fire—or if you will, a nuclear reactor with a coal furnace. As all of you know,

ordinary combustion is a chemical reaction. It involves merely a rearrangement of extra-nuclear electrons.

Prior to December 2, 1942, all man-released energy was of this kind—that having to do with the rearrangement of the electrons in the outer orbits of the atoms. When you burn coal, an atom of carbon combines with two atoms of oxygen.

When three atoms combine in this manner, the resulting mass is just a little bit less than the mass of the sum of the three atoms separately. Not very much, indeed, it could never be measured, but the loss of mass manifests itself in the emission of radiant energy. As you know, when you burn a pound of good coal you liberate some 12,000 B.T.U.'s, assuming good combustion. In the formation of carbon dioxide, each molecule liberates 1.5 electron volts.

Note that when I refer to the energy release of a molecule I don't use the unit B.T.U. The B.T.U. is far too large an energy unit to use in dealing with the energy of individual atoms or molecules. The electron volt—which is not a unit of potential but of energy—is much more convenient. So, then, when two atoms of oxygen and one of carbon combine to form a molecule of carbon dioxide, $1\frac{1}{2}$ electron volts of energy are released. This energy release is in accordance with Einstein's famous equation $E = MC^2$ where C represents the velocity of light.

Now, normally when you have a mass of carbon and oxygen together nothing happens until you raise the temperature of at least a small part of the mass to a high temperature—the kindling temperature. When you do that, what you do in effect is to impart greater velocity to the random movement of the atoms. When some of them get to moving fast enough, some of the electrons are knocked out of the outer orbits of the atoms and the combination mentioned

(Continued on Page 8)

Mr. Kramer is Editor, *Power Engineering* magazine. He was an observer during the Bikini A-bomb tests. Mr. Kramer gave this talk before the Junior Division of the Western Society of Engineers at the Society's Headquarters on March 24, 1953.

(Continued from Page 7)

previously takes place with the resulting liberation of energy. This energy is absorbed by the adjacent atoms, thus imparting further velocity to them, again causing electrons to be removed from some of the atoms. It is easy to understand that once a sufficient number of atoms have released energy in this way, the entire mass will become involved, and so a chain reaction is obtained.

This is a somewhat cumbersome way of explaining what happens when you light a coal or wood fire, but it is well to remember that this process of energy liberation depends upon the Einstein equation in just the same way that the nuclear reactions in atomic explosions depend upon it.

Until Fermi started his knob-shaped nuclear pile at the University of Chicago on December 2, 1942, as I said, all our energy was the result of these electronic rearrangements.

In the meantime, however, it had become known that much greater stores of energy resided in the nuclei of the atoms. How we knew that is a long story beginning in 1895 with Roentgen's discovery of X-rays and extending all through the first four decades of this century, but there is not space to go into detail. A few facts however, may be of interest.

As all of you know, the discovery of radioactivity first made scientists real-

ize that the atom was not the simple indivisible entity it had been thought to be. The release of almost inconceivable amounts of energy from radium, day after day, year after year, indicated that the atom was a complex structure, and this knowledge set off a tremendous amount of research and experiment.

In time, it was found that the nucleus of the atom was itself a complex structure containing various kinds of particles carrying positive and negative electrical charges. At first it was thought that the nucleus contained only two kinds of particles—protons, carrying positive charges, and electrons, carrying negative electric charges.

The proton and the electron were known to have approximately equal but opposite charges but the mass of the proton was known to be some 1800 times greater than the mass of the electron.

According to this theory, the simplest of all atoms was the hydrogen atom which consisted of a single proton as the nucleus, with one external electron traveling around it in an orbit.

This theory is still valid.

The next atom in the scale of atomic weights is the helium atom. This was thought to consist of a combination of four protons and two electrons in the nucleus and two external electrons in outer orbits.

Electrically, this atom is balanced—neutral.

As far as the nucleus itself is concerned, there is an excess positive charge, and since like charges repel, it is difficult to understand how such a nucleus can hold together, even though the excess positive charges are balanced by the negative charges of the two external electrons.

Remember, like charges repel each other in accordance with the inverse square law—when the particles are very close together, the repulsion between the particles is relatively enormous. How, then, is it possible for the four protons to remain in the nucleus in this fashion? Whatever the real explanation is,—and we are not sure—it is evident that at very short distances, another kind of force predominates—an attractive force, which holds the particles together despite the Coulomb repelling force.

It is very much as if the particles were coated with an extremely strong sticky glue. Once they are actually brought in contact they stick together, even against the repelling force.

With this kind of a nuclear structure, it was thought that if high speed projectiles could be shot at atoms, it might be possible to smash the nucleus so that the bond between the particles would be broken, and they would fly apart.

And so, this was tried out in many different ways. The projectiles, of course, had to be small, so at first we used the particles which were thrown off spontaneously by radioactive substances, such as radium. These were the alpha particles.

Later, electrons and protons (ionized hydrogen atoms) were accelerated by high electric potentials in vacuum tubes and then used to bombard all sorts of atoms.

The difficulty with this method was that as the charged projectiles came close to the nuclei of the atoms, the powerful repelling force of the nuclei deflected the projectiles, and only occasionally, with a head-on collision were we able to actually hit a nucleus. When such head-on collisions were achieved, the thing that we hoped would happen, actually did happen. The process, however, was extremely inefficient and much more energy was needed to speed up the particles than was obtained from the nuclear disintegrations. You see, with

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say a million projectiles, we would only hit one nucleus.

In the meantime, other theories of nuclear structure were being considered, one of which was of great theoretical interest because it suggested the possible existence of an entirely new undiscovered particle—a particle that was believed to result from the neutralization of the electric charge of a proton by an electron, leaving a neutral, uncharged particle having unit mass. This theory was advanced by different investigators as early as 1920.

The actual discovery of the neutron, however, did not come until 1932, when James Chadwick, in England, showed that certain radiations which others had observed but not understood, were actually streams of neutrons—neutrons which had been knocked out of nuclei by the heavy alpha particles from radium.

The discovery of the neutron was an event of world shattering significance although at the time it received little notice. For the first time, scientists had

a particle which would not be repelled by the powerful positive charge on the nuclei of all atoms, and they began, at once, to use it in all sorts of ways. At the same time the discovery of the neutron gave us a new and better concept of the structure of the nucleus. Instead of having electrons, as such, in the nucleus, now we had neutrons. On the basis of this concept, the helium atom, which I mentioned a while ago, has two external electrons in the outer orbit, and a combination, in the nucleus, of two protons and two neutrons. Of course, you can still think of the neutron as a proton which has swallowed an electron, but in many ways this new concept of the nucleus is more satisfactory.

Among the many elements which were bombarded was Uranium, the heaviest and most complex of all natural elements.

Before I go further, I might call your attention to another aspect of nuclear structure that the neutron concept clarified. That is the explanation of isotopes

—elements with the same chemical properties but of different atomic weights. The simplest isotope is the first isotope of hydrogen—heavy hydrogen—known as deuterium. The nucleus of this atom consists of a proton and a neutron. Now, remember, it is the number of protons that determines the number of external electrons, hence the chemical properties of the element. There is another isotope of hydrogen, one consisting of a proton and two neutrons. This is called tritium, and it has considerable importance at the present time.

As you all know, there are only 92 natural elements. Hydrogen is the simplest, with one proton, and Uranium, with 92 electrons, the most complex. As we go up in the periodic table, the number of protons in the nucleus increases by one with each element.

The number of neutrons, however, varies considerably. In the lighter elements, the number of neutrons is equal to the number of protons but as we go
(Continued on Page 16)

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America's Urgent Need for Modern Industrial Exhibit Facilities

IN last month's *MECHANICAL ENGINEERING*, I made reference to the great industrial expositions which were held during late summer and early autumn in Germany, England, and Italy.

One of the most notable features of the exhibits, especially those at Hannover and London, was the extent and character of the exhibit halls and grounds in which the shows were staged. These have no parallel in this country.

West Germany, determined to make Hannover the logical successor to Leipzig as the recognized locale for commercial and industrial fairs, has created an exhibition ground fifteen minutes by taxi from the center of the city, comprising several acres of land, nine buildings of the most modern character, and over 700,000 square feet of exhibition space. Every possible facility is available for the expeditious handling of even the heaviest equipment, in and out. At the Continental Machine Tool Exhibition, there were no less than twelve separate restaurants in operation to handle the capacity crowds. Tramways and buses provided direct access to the grounds, and a vast parking lot was available.

Olympia, which is London's counterpart, is less spacious, but hardly less impressive. Housed in a single great building on Knightsbridge near the very heart of London, its galleries, as well as its main halls, are designed to take heavy floor loads. Within or immediately adjacent to Olympia are railroad sidings with loading docks, a station of the London Underground rapid transit, several restaurants and meeting halls, and a large and completely modern ramp-type parking garage.

Even Italy possesses, in the great Turin exhibition hall with a wholly unobstructed main floor area in excess of 165,000 square feet, exhibition facilities which are superior in many respects to anything we have in this country.

It is shocking that the United States, the world's greatest industrial nation, possesses no facilities for industrial exhibits which begin to parallel either of these. In the coming struggle for our share of the world's business, this defect should be remedied.

New York would be an ideal locale for a permanent fairground comparable to that of Hannover. So would Chicago and Detroit.

Certain groups in this country are already studying the possibility of developing interest in financing and constructing such an exhibition space, either among hotelkeepers and others who might benefit by the crowds which public exhibits attract, or perhaps among municipal, state, or federal governments.

Engineers have what the actuaries would call an insurable interest in such a venture, for there is perhaps no greater stimulus to engineering development and constructive redesign of product than a periodic industrial exhibition. Any sound program for the establishment of a great exhibition center within our borders deserves support, especially from a profession such as ours, to which industrial exhibitions are largely directed.

FREDERICK S. BLACKALL, JR., *President*
The American Society of Mechanical Engineers

(Reprinted from an editorial in *Mechanical Engineering*, March, 1953)

The Case of the Vibrating Stack

By Dr. Donald J. Bergman

This case had its beginning in a report dated 1937 from a field construction engineer on the island of Bahrein in the Persian Gulf. The report was brief, merely that the stack for a heater on a Thermal Cracking Unit had developed an alarming sway, and that permanent guys had to be installed.

This stack, 3' x 90', had been designed as a self-supporting unit for a 100 m.p.h. wind. A quick check on the design basis showed no errors, so other causes were looked for. Bahrein was sandy, so the foundation was not solid. But rock was just under the sand and the foundation rested on the rock. The stack had been shipped in two pieces, and field riveted. That must be it. So the guyed stack gave no more trouble.

Then a report dated December 3, 1940 came from England in connection with a 6'-6" x 130' stack on a dehydrogenation unit.

In this case the stack had just been erected when a storm came up with winds checked at the Meteorological Department as being a maximum of 45 to 50 m.p.h. The stack vibrated $7\frac{1}{4}$ " each side of perpendicular based on transit measurements. It was particularly noted that in bending, the stack ovaed. So it was decided to weld stiffening angles around it at intervals and attach permanent guys 90 feet above the base.

From an office report dated April 28, 1941 I quote: "A thorough study of all the literature and periodicals for the past 25 years listed in the Engineering Index, The Applied Arts Index, the U. S. Catalog, and a search in the card index files of all the major libraries in Chicago on the subject has disclosed only three articles in periodicals that made any attempt to work out the problem of vibrations in stacks, and these articles, two of which were in Beton & Eisen in 1928 and one in the Engineering News Record of 1934, were not definite in their conclusions." . . . "All of the facts hereinbefore outlined bring us to the conclu-

sion that the foundation was put on soil that was inadequate. At 50 m.p.h. the maximum toe pressure under the foundation was around 1100 pounds per square foot, and apparently the soil couldn't take this amount for the stack rocked back and forth, and the foundations with it."

However, the matter did not rest there, for we were assured from England that their soil was not poor and it must be our stack that was wrong because although it was designed to deflect 4.36 inches for a wind pressure of 25 p.s.f. with a 100 mile wind, actually a 50 m.p.h. wind with only 6.25 p.s.f. resulted in $7\frac{1}{4}$ " deflection each side.

So studies were made to determine the natural period of vibration of the stack, by an approximation method, based on the article in Beton & Eisen.

Also the Engineering News Record article mentioned Von Karman's work on eddy trails and gave a formula for the frequency of eddies from a cylinder as being

$$F = 0.27V \frac{D}{D}$$

where

F=Frequency

V=Velocity of wind m.p.h.

D=Stack diameter feet

Calculations indicated a frequency of 1.6 vibrations per second as the natural frequency of the stack. This corresponded with the wind frequency for 40 m.p.h. for this 6'-6" x 130' stack. So there was apparently some resonance set up at the particular wind velocity of 40 m.p.h.

Then Sir James Jeans' book *Science and Music*, published in 1939, was read in pursuit of information about tempering a piano, and in it were found pictures showing the eddies resulting when an obstacle was drawn through water, and also a reference to wind whistle.

The book says that experimentation has shown that whenever wind passes over a distance equal to 5-2/5 times the diameter, a whirlwind is formed, making it possible to calculate what the pitch of the note is. For instance, we might be sailing on the ocean with a 40 m.p.h.

wind blowing through rigging made up of $\frac{1}{2}$ " ropes. Arithmetically we easily find that the rate of 40 m.p.h. is 704 inches per second. The wind, therefore, traverses 1408 diameters of the $\frac{1}{2}$ " rope every second. If this number, 1408, is divided by 5-2/5, we find that the frequency of the whistle of the wind is 261 cycles every second, or middle C on the piano. If the velocity of the wind increases, the whirlpools form at a quicker rate, and the pitch of the whistle of the wind rises. The frequency is exactly proportional to the velocity of the wind.

The book says further that each one of the whirlpools not only gives a shock to the air, but also to the obstacle which causes the whirlpool in the first place. The obstacle is pushed back and forth as the whirlpools form alternately on one side then the other. You see the results of these pushes as a flagstaff flaps in the wind, while the flag atop the pole flutters as one whirlpool chases another one along the length of the flag.

Here for the first time—and in a book on music—was found a clue that the vibration of the stack was not from successive gusts causing a to and fro motion of the stack in the direction of the wind, but was actually a crosswise motion which coincided with one observation from the field. Incidentally, this matter of observing such small details is one of the most difficult—and necessary for an engineer.

Now may we look at a formula for the period of oscillation of a cantilever beam as given in *Aircraft Vibration and Flutter*.

$$F_n = C \sqrt{\frac{g EI}{W L^4}}$$

F_n=Natural frequency

C=Constant depending upon the mode of vibration

Mode #1—C=.560

Mode #2—C=3.51

Mode #3—C=9.82

g=Acceleration of gravity 386 in./sec.²

E=Modulus of elasticity, lbs./in.²

(Continued on Page 12)

Dr. Bergman, Chief Engineer, Universal Oil Products Company, Des Plaines, Illinois, presented this talk before the Western Society of Engineers at the Society's Headquarters on February 2, 1953.

(Continued from Page 11)

I = Moment of Inertia, in.⁴

W = Weight of beam, lbs./in.

L = Length of beam, inches

Since a stack may be subjected to any wind velocity up to its design basis of 100 or 125 m.p.h. it may be subjected likewise to the complete range of vibration frequencies given by the formula

$$F = 0.27 \frac{V}{D}$$

Luckily many stacks are never subjected to a full trial of wind velocities.

So the problem is to get the stack out of that complete range of frequency in some manner.

It will be noted that L is the most important dimension, for frequency varies inversely with L^2 . It was just such a change, from 90 ft. to 125 and 150 ft. stacks, that got us in trouble.

For a stack the Moment of Inertia $I = \pi (D^4 - d^4) / 64$ where D and d are outside and inside diameter.

An approximation is obtained by expanding $(D^4 - d^4)$ to $(D^2 + d^2)(D + d)(D - d)$ or $2D^2 \times 2D \times 2d$ so that $I = \pi t D^3 / 8$

The stack weight W lbs. per foot is proportional to $t D$. When these are both entered in the frequency formula, t cancels out.

So it may be seen that adding thickness to the stack has no effect except to increase the forces involved when the stack gets into resonance with the wind.

However, addition of a brick liner inside the stack, which increases W , without correspondingly increasing I , will change the period. In addition, such a liner has a damping action by absorbing some of the energy picked up from the whirlwinds.

Increasing diameter of the stack results in a reaction in the imposed wind frequency, and also increases responding frequency of the stack.

However, a stack is usually designed to meet certain draft and capacity conditions which fix the diameter and height, rather than some relation to keep out of vibration trouble.

How then can a stack which is in the vibration zone be corrected to keep it out of danger? A tip may be taken from the rigging of light racing sailboats.

Considering the various modes of vibration, in all cases the end is free to snap back and forth as a whip, while the bottom is fixed and one or more nodes also remain fixed.

A ring may be provided at a distance of something more than half the length from the bottom ($4/7$ seemed to be a good number) and three spreaders extended outward at 120° , each approximately the diameter of the stack. Three light guys are dropped from a ring near the top of the stack to the end of the spreaders and then brought in to the cone or base of the stack. At the bottom they should be provided with springs to allow for the difference in expansion between stack and guys.

This, in effect, changes the deflection curve of the stack from that of a simple cantilever fastened at the ground, and giving $1/4$ of a full sine wave to a much more complicated form, more like a full sine wave, but for the rigidity at the base, and with a frequency at least four times that of the basic natural frequency of the stack.

It might be thought that this phenomena would only be found in connection with strong winds, but the following incident shows otherwise.

In 1945 during a trip to the Dutch Island of Curacao, discussion brought out that two $5' \times 175'$ stacks had developed an alarming sway on two occasions, and following the second time they had been guyed. A letter was found in which the amount of sway was given as $18''$ maximum at the top while the base moved only $5/16''$, corresponding to about $6''$ at the top. Further, the frequency had been determined to be about 48 cycles per minute.

A little mental arithmetic indicated that the trouble was encountered in a 15 m.p.h. wind, and this seemed too low a velocity to cause that much disturbance. However, a trip to the airport near the refinery and a check into the wind records showed that at the particular time when trouble was occurring, the wind velocity was from 14 to 16 m.p.h. It had been noted that at higher velocities the vibration stopped. In fact, several times when vibration was bad and measurements were to be taken, by the time a transit could be set up, everything had quieted down even though the wind velocity had gone up to a normal of about 20 m.p.h.

It is interesting to note that books on

Fluid Dynamics, which is a comparatively young offshoot of modern engineering, commonly give diagrams showing the distribution of pressure around a cylinder in a flowing stream as a cat headed figure, completely symmetrical about the wind axis. Usually, within a few pages, a diagram or photograph of the Von Karman trails will also be shown. Only slight further consideration develops the fact that the symmetrical figure is the result of a time average of pressure tap readings taken for various points around the circumference of the cylinder and not the instantaneous readings which would show the alternating side to side forces set up as the result of the formation of successive eddy and stream line flow at regular intervals on each side of the stack.

Perhaps in a few more years this problem, which is identical with that of the Tacoma Narrows Bridge, will be more thoroughly recognized, and engineers will be able to find the cause without seeking in the field of music.

In analysis of these problems, three charts are used; one gives the wind frequency for various diameter stacks and wind velocities. The other sheets give approximated resonant frequencies for vessels or stacks from $2'-6''$ to $6'-0''$ and for $6'-0''$ to $12'-0''$ diameter for heights up to 200 feet, for the first three modes of vibration.

The range of frequencies to be encountered up to maximum wind velocity is compared to the resonant frequencies for the particular diameter and height, and if they coincide, the spreader treatment is applied. Since then we have had no further vibration problem. In general, any stack with a slenderness ratio of over 20 should be suspect.



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S.S. United States

(Continued from Page 5)

ship can operate without sufficient electric power.

The ship's service power is alternating current, a deviation from the conventional that aided materially in reducing weights. Other important advantages in the use of alternating current are the reduced maintenance necessary on squirrel cage induction-type motors, and the ability to apply extensively simple across-the-line AC controllers.

Some motor driven auxiliaries which do not function satisfactorily on alternating current because of the inherent lack of simple, wide range, speed control under varying load conditions—among them cargo winches and elevators—are run on direct current supplied by especially adapted generator converters.

The AC generators, which provide ship's service power, together with their associated control switchboards, were so located as to minimize the possibility of simultaneous damage to the several units. The ship's service lighting system, small and fractional horsepower motors, and other appliances were arranged to operate at reduced voltage, obtained from the ship's service power sources through banks of transformers located at several electrical load centers. Normal and alternate feeders were provided at the load centers to insure continuity of service in the event of interruption to the normal supply.

In the event of failure of all or part of the ship's service electric generating plant or distribution system, a completely separate emergency power system automatically takes over, providing the illumination necessary for the safety of the personnel, and operating certain vital communications and damage control equipment. Storage batteries supplying current to special AC-DC units temporarily take over during the interim while the emergency Diesel engine driven generators are coming up to speed and while the automatic transfer operations are taking place.

Inasmuch as the overall electrical installation aboard the *UNITED STATES* is undoubtedly the most advanced and complex such installation aboard any commercial vessel in the world, it may be of interest to outline briefly some of the major auxiliaries and devices dependent on it.

The elevator installation comprises nineteen automatic elevators, ten of which are for passenger use, and the remainder of which are for cargo freight handling, food and luggage, and for engineering and deck officer personnel. The combined capacity is over 30 tons, and the total lift is approximately 1,000 feet. The elevators are equipped for operation by either the passenger or regular attendants. All elevators are equipped with "full-collective" controls, which "remember" all calls, answering all "up" calls on the "up" trip, reversing direction at the top, and answering all "down" calls on the "down" trip.

The boat davits, featuring new developments in trackway and releasing gear, are powered by AC motors, and are provided with conveniently arranged push-button stations, emergency stops, and limit switches acting in a specially designed control circuit.

The cargo winches installed on the *UNITED STATES* were selected because each pair of winches has its own motor generator set, resulting in maximum operating efficiency.

The electric galley and commissary equipment is very extensive, since a total of at least 9,000 meals must be served each day to the 2,000 passengers and 1,000 crew members. Radar ranges, several of which are installed aboard the *UNITED STATES*, are among the more unusual pieces of electrical galley equipment. By means of the high-speed cooking inherent in the Radar range, the chef can fry an egg in 12 seconds, a pork chop in 50 seconds, bake an apple in one minute, reheat a pie in 10 seconds, or prepare a ham and egg sandwich in 25 seconds.

To give some idea as to the magnitude of the electrical installation the following figures may be of interest:

Cable: More than 50 miles of power feeders alone—not counting the vast amount of control wiring.

Circuit Breakers: More than 1,300, many of which are electrically operated.

Fused Tumbler Switches: Approximately 700.

Motors: More than 2,300 ranging up to 400 HP.

Switchboard Meters, Instruments: Approximately 150.

Galley and Commissary: Approximately 250 ranges, ovens, griddles, fry kettles, toasters, waffle irons, broilers

and miscellaneous motor driven units such as slicers, dishwashers, mixers, blenders, cutters, extractors, choppers, peelers, etc.

The basic mandates controlling the lighting arrangements aboard the *UNITED STATES* were that the lighting installations should be effective and efficient, unobtrusive, concealed wherever practicable, flexible, safe, harmonious with the surroundings, and pleasing to the user. As a result, the lighting is mixed. Incandescent lighting is used in living and working spaces, while passage-ways, stairhalls, and stairways are lighted by fluorescent tubes having color temperature known as soft white. This color was selected because it brightens reds and tans and gives an attractive color rendition to "make-up," an important item to the women passengers. The illumination requirements of this installation are met by some 34,700 incandescent lamps and fluorescent tubes, connected by 70 miles of cable.

The ship's radio transmitters and receivers cover all of the frequencies allocated to commercial use on the North Atlantic. Ship-to-shore radio telephone apparatus permits a passenger in any stateroom on the ship to place a telephone call to almost any other telephone in the world. Entertainment radio receivers located in a central control station provide, in public spaces and recreation areas, a selection of commercial broadcast entertainment, and entertainment in the ship's ballroom can, in turn, be made available to land radio stations for re-broadcast.

Centralized within the Safety Room, which is manned on an around-the-clock basis, are the controls and warning mechanisms of the various indicating and alarm systems which help to maintain the high standards of safety afforded to all who are aboard the *UNITED STATES*. Among them are those for smoke detection, fire alarms, carbon dioxide fire extinguishing system, fire screen and watertight door controls, ventilation and air conditioning fan controls, various emergency alarms, annunciators and telephones.

Some of the important navigation and communication installations aboard are as follows:

Two master Gyro compasses with a large number of repeater compasses.

(Continued on Page 14)

(Continued from Page 13)

Two Loran units, a Decca navigator, and a radio direction finder.

Two Radar units, one a 3-centimeter and the other a 10-centimeter wave length, each with simultaneous scope presentation in Bridge and Chart Room.

Echo sounding equipment for recording depth of water and charting the ocean floor.

Pitometer log for speed indication.

Gyro Pilot for automatic steering control.

Rudder angle and shaft revolution indicator.

Sound powered telephones for ship's personnel.

Manual telephones for passenger use.

Call bell system in each stateroom and Public Space for the convenience of the passengers.

Automatic dial phones for communication between ship's operating departments.

Announcing and Public Address systems.

The use of new materials and equipment was not limited to the construction of the vessel alone. During the trial trips a new speed measuring device was used. This speed measuring device is called Raydist. It was developed by the Hastings Instrument Company, Hampton, Virginia. It was the first recorded trial trip on which such a device was used, and it gave the most accurate measurement of a ship's speed ever recorded. In the past, trials were run close to shore within sight of two markers located a nautical mile apart. The only two such measured mile courses on the Atlantic Coast are located in Maine and Cuba. To use either of these courses would have consumed considerable time and money in traveling from Newport News, Virginia, to either Maine or Cuba. It was also recognized that if either of the courses were used, any person aboard the vessel during the trials could, within certain limits, check the speed of the ship by observing the shore markings. It was therefore decided to use the Raydist system during the trials. At the time of the trials, a Coast Guard cutter proceeded to deep water where an electronically equipped buoy, which was not anchored to the bottom, was dropped overboard. The *S. S. UNITED STATES* was then steered away from the buoy in different directions and later turned around and headed back to it. In spite of near-hurri-

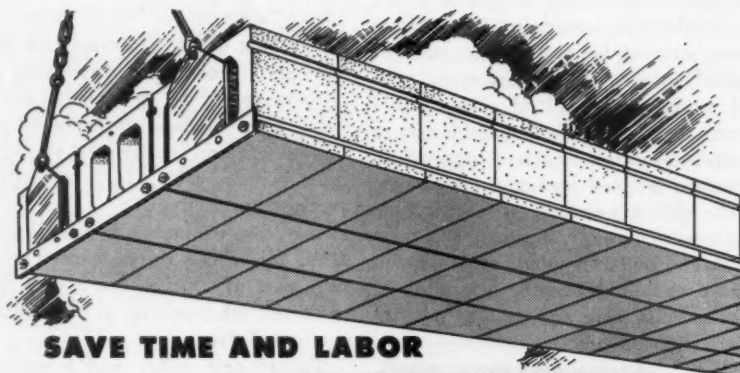
cane weather, the trials were eminently successful, and the *UNITED STATES* moved through the high seas as though she were riding in a mill pond. The small bow wave, the small amount of water thrown forward at such high speeds, the markedly small amount of pitching and rolling—all justified the many model tests carried out during the early development of the design.

On her maiden voyage the *UNITED STATES* averaged better than 35 knots for the combined East and West cross-

ings, breaking all speed records and capturing the Blue Ribbon of the North Atlantic, which had not been held by this country for 100 years.

This average speed is equivalent to a land speed of more than 40 miles per hour. This may appear to be a low speed in comparison to a modern automobile, but when one considers the fact that the vessel is equivalent in length to five city blocks, the feat is stupendous.

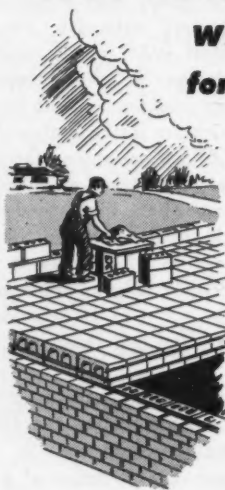
During her first ten round voyages the *UNITED STATES* has averaged ap-



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proximately 31 knots, a speed which has never before been approached by a ship over such a distance. This is particularly interesting when it is realized that this is equal to two and a half times around the world, and exceeds the best announced single-day's run for the *QUEEN ELIZABETH*. In other words, the *QUEEN ELIZABETH* had not been able to maintain for a full day a speed that the *UNITED STATES* has successfully maintained for ten round voyages. This is also interesting when compared to the speed attained by the *QUEEN MARY* when she made her record crossing one-way—31.69 knots—only about two-thirds of a knot faster than the sustained average of the *UNITED STATES*.

To give an idea of the vessel's ability to travel in bad weather, on one of her recent voyages the wind was so strong that a larger European liner travelling the same course practically "hove to" for repairs at sea, since she had 18 airports broken and had certain of her passenger accommodations flooded. The *UNITED STATES*, meanwhile, maintained a cruising speed of well over 30 knots, since she sustained damage of only a superficial nature.

Here are a few statistics which may be of interest:

Length overall: 990 feet (140 feet higher than 70-story Rockefeller Center).

Beam: 101 feet 6 inches.

Depth: Keel to top of superstructure—122 feet. Keel to top of stack—175 feet (equal to a 12 story building).

Stacks: largest in world—all aluminum—55 feet high—60 ft. long.

1,200,000 aluminum rivets.

First passenger ship built in a dry-dock.

2,200 pre-fabricated assemblies installed (weighing up to 100 tons each).

1,500 miles of welding.

Material from 48 states filled 1,500 freight cars.

Some of the 26 Public Spaces for the use of the three classes of passengers are as follows:

Extensive game areas for deck tennis, shuffleboard, etc., observation lounge, ballroom lounge, cocktail lounges, reading and writing rooms, two modern theatres, children's playrooms, shopping centers, monel metal swimming pool, and a modern dog kennel.

It may be of interest to emphasize sev-

eral additional points in regard to her dual-purpose existence. This country, in its desire for self-preservation, must supply itself with a constantly changing armory of weapons. The primary purpose of these weapons is either to deter an enemy before he commits an act of aggression or to contain and defeat him after the commission of an aggressive act. Of what use are tanks, big guns, rifles and the host of other weapons, if they—and the men who use them—cannot be brought into prompt and effective contact with the enemy? The weapon that transports these men and their equipment—speedily, safely, and fit to fight—to a vital spot therefore becomes of great value and importance. In the *S. S. UNITED STATES* we have just such a weapon—one capable of so transporting, on a moment's notice, nearly 14,000 men to any port in the world.

The overall final cost of the *UNITED STATES* has been reported as approximately \$72,000,000. Of this amount, the owner, The United States Lines, is paying \$29,000,000, the amount fixed upon by the Maritime Administration as the cost of building a comparable vessel, with no national defense features, in a foreign shipyard. The Maritime Administration is paying \$19,000,000 to cover the extra amount that it cost to build this ship, without defense features, in an American shipyard, using American labor and materials, and helping to keep healthy America's vital shipbuilding industry. The many National Defense features built into the *UNITED STATES* were estimated to cost \$24,000,000. This cost was approved by the Navy.

Recently several governmental agencies have criticized the original contract under the terms of which the Government paid such a large amount toward the building of the *UNITED STATES*. During World War II this country had to pay for each G. I. carried to and from foreign soil on all ships owned by our allies. It has been stated that these payments amounted to approximately \$1,000,000 for each voyage made by the *QUEEN MARY* and the *QUEEN ELIZABETH* in this service. Simple arithmetic shows that the *UNITED STATES* could, under war conditions, pay for herself in a remarkably short time.

Nearly all of the weapons used in war are paid for in whole by the Government. Yet such is not the case with the *S. S. UNITED STATES*. She is being

paid for only in part by the Government. In order that this potent weapon may be ready when needed, her owners—The United States Lines Company—have contributed \$29,000,000 towards her construction. For this sizeable sum they they have the right to operate her during peacetime life. But they are also bound to maintain her in a state of constant readiness, and she may be reclaimed whenever the Government so desires. She may never be sold without permission of the Government, and then not at a price higher than was paid for her. Finally, during her peacetime use as a passenger liner she is an aid to the economy of this country through the money she earns and through giving employment, directly and indirectly, to thousands of American citizens, and any profits over a reasonable amount are recaptured by the Government.

It is with real pride that we can realize that modern American ships are the world's safest and that the *S. S. UNITED STATES* far exceeds any of the others and has unique value for our national defense.

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The Whole Loop at its Doorstep

Atomic Energy

(Continued from Page 9)

higher in the periodic table, the number of neutrons becomes proportionately larger. Thus, when we come to the element Uranium, we find that its nucleus consists of 92 protons and in the neighborhood of 143 neutrons.

Note that I say in the neighborhood of 143, because there are three isotopes of Uranium—Uranium 234, Uranium 235 and Uranium 238. Thus U-235 consists of 92 protons and 143 neutrons. U-238 consists of 92 protons and 146 neutrons.

When the neutron was discovered, scientists immediately began to use it to bombard all kinds of elements, and among the many was the element Uranium. As early as 1933 Fermi, working in Italy, bombarded Uranium with neutrons and got some curious results which were not fully understood at the time. At the same time in France, in England and the U. S. and in Germany, other experimental work involving the neutron was in progress.

In the latter part of 1938 two German physicists, Hahn and Strassman, in bombarding Uranium with neutrons found traces of barium and other elements among the disintegration products, and these were difficult to explain. First they mistook the barium for radium, but subsequently—early in 1939—they confessed their error and admitted that it was barium. In the meantime another investigator, Professor Leis Meitner, a woman who had worked with Hahn but who had been forced to leave Germany because of Nazi pressure, and had found refuge in Stockholm, read Hahn's paper and immediately had the answer. With her nephew, Professor Frisch, Meitner wrote a letter to the Editor of *NATURE*, dated January 16, 1939. In this letter they said, "It seems therefore possible that the uranium nucleus has only small stability of form, and may, after neutron capture, divide itself into two nuclei of roughly equal size . . ."

Note that statement "two nuclei of roughly equal size."

Here was nuclear fission!

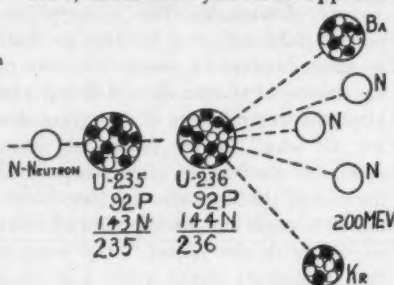
And then, they went on—"These two nuclei should gain a total kinetic energy of (about) 200 million electron volts."

Two hundred million electron volts from one splitting atom—ten times as

much as had ever been gotten from atomic bombardment.

Here was atomic energy.

Now, let me show you what happened:



This, then, is nuclear fission.

Now, the important thing about this process is not so much the splitting of the nucleus as the fact that in the process, several neutrons are liberated.

As I have explained, as you go up in the periodic table, the number of neutrons with respect to the number of protons increases. The additional neutrons seem to be necessary to hold the protons together. Therefore, when the U-235 nucleus splits, the resulting fragments tend to have more neutrons than they need; hence these are liberated.

Now, it should be evident that if the original fission was caused by the absorption of a neutron, each of the liberated neutrons should be able to cause fission in other uranium nuclei, if such nuclei happen to be around.

And, this is so. These released neutrons can cause fission in other uranium nuclei.

This was recognized in 1939 when the news of these experiments and Meitner's conclusion swept around the world. It appeared that a chain nuclear reaction was possible.

However, it was realized that there were obstacles. To begin with, it was found that only uranium 235 undergoes fission. Uranium 238 and uranium 234 do not. And natural uranium is a mixture of these three isotopes. But there is much more U-238 than U-235—in fact natural uranium is composed of 99.3 per cent U-238 and only 0.7 per cent U-235. The amount of U-234 is negligible—there is only a trace.

It was realized that these U-238 nuclei would absorb neutrons without undergoing fission. Hence, such captured neutrons would be lost.

Also, it was known, that in a certain mass of uranium, a certain number of neutrons would escape from the surface

and these also would be lost.

So, to test the validity of the idea, it was first necessary to separate a quantity of U-235 from natural uranium, if possible, or at least to get together a sizeable amount of pure *natural* uranium so as to build some sort of pile.

Another interesting fact was known, and that was that fission was much more likely to happen if a slow moving neutron was captured than if it were a high speed neutron. Remember, in the process of fission, the released neutrons are ejected at tremendous velocities.

It was obvious that it would be necessary to slow these neutrons down before permitting them to be captured by other U-235 atoms. One method of doing this was to have them pass through material which would not absorb them but which by successive collision would reduce their speed. Several substances suggested themselves. Heavy water, i. e., water composed of the heavy isotopes of hydrogen and oxygen. This was extremely rare however.

Another suitable substance for a speed moderator was graphite—*pure* graphite. It was thought that if neutrons could be caused to pass through a certain thickness of graphite, their speed would be reduced to the point where it would be effective in causing fission.

So, as you all probably know, it was decided to build a "pile" consisting of blocks or bricks of pure graphite in which slugs of uranium metal were embedded in the form of a lattice.

The theory was that neutrons produced by fission in one slug would have to travel through a thickness of graphite before they could reach atoms of uranium in adjacent slugs. The idea was simple enough. The great difficulty lay in obtaining pure materials.

Another factor was involved. That was the fact, which I mentioned before, that a certain number of neutrons would escape from the surface and so be lost.

Now, simple spherical geometry tells us that the relative number of neutrons that escape from a mass of uranium can be changed by changing the size and the shape. In a sphere, any surface effect is proportional to the square of the radius, whereas any volume effect is proportional to the cube of the radius.

This being so, it is quite evident that the escape of a neutron from a quantity of uranium is a surface effect, depending upon the area of the surface

but that fission capture occurs throughout the mass of the material and is therefore a volume effect.

Consequently, the greater the volume, the less probable it is that neutron escape will predominate over fission and prevent a chain reaction.

Well, you are all familiar with the story—how under the direction of Fermi, the first atomic pile was built, layer by layer under the football stands at the University of Chicago and how, on December 2, 1942, the pile became critical, and the first nuclear chain reaction in the world was established.

One thing I have omitted. How did the chain reaction start—how was fission induced in the first uranium nucleus? The answer is, it started itself. Because of the cosmic rays which are continually reaching the earth from outer space, at any instant some uranium atoms are always undergoing fission. So, as soon as the pile reached the critical size, and the number of neutrons produced became greater than the number escaping from the surface or captured by nonfissionable nuclei, the reaction became self sustaining.

When this first man-made nuclear chain was established, man had succeeded in causing the rearrangement of the nuclear constituents of matter on a scale comparable to that involved in ordinary chemical combustion.

Since the forces which hold the particles of the nucleus together—the neutrons and protons—are incomparably stronger than those which hold the extra nuclear electrons in their orbits, it is to be expected that the energy liberated when a uranium nucleus splits, is tremendously greater than when a carbon atom combines with an oxygen atom. As I have already pointed out, in the formation of a molecule of carbon dioxide, the energy liberated is $1\frac{1}{2}$ electron volts. When an atom of uranium splits, 200 million electron volts are released.

Looking at it another way, when we burn a pound of coal we release about 12,000 B.T.U.'s. When a pound of U-235 undergoes fission, 40 billion B.T.U.'s is released. One pound of U-235 has as much heat energy in it as 1260 tons of coal.

As columnist Sam Grafton once said, there is enough atomic energy in a battle ship to drive a toothpick twice around the world or something.

What I have described is called a

nuclear reactor. In a sense it is a furnace in which we burn nuclear fuel.

When an ordinary chemical fire burns, it gives off heat, light, and products of combustion. In addition it requires oxygen, and an original charge of fuel.

In analogous fashion, when a nuclear fire burns, or when a nuclear reactor reacts, it gives off heat, a sort of light, and products of nuclear combustion; in addition it requires original fuel (U-235 or Pu) and, in a sense, it requires an atmosphere of neutrons rather than of oxygen.

Now what are the advantages of this kind of a furnace over our existing fuel-fired furnaces?

First, compactness. Compared to a modern boiler, a nuclear reactor—that is, the reactor part of it—is very small. The amount of energy that can be released in it is almost beyond belief.

Second, it requires no atmosphere of oxygen.

These two factors make the nuclear power plant tremendously attractive to the military, for propulsion of ships and aircraft. The fact that no atmosphere of air is required makes it of inestimable value for submarine propulsion, and that is why it is taking a cold war to stimulate the development of reactors of all kinds.

Many people who have watched the development of our atomic energy program from the side-lines, so to speak, and even some actually concerned with it, have deplored the fact that practically all of it is directed toward military purposes.

This of course is true, but it must be remembered that a vast amount of original research underlies all the work, and the basic data is equally useful for military and non-military purposes. The millions of dollars spent for research and development for submarine reactors will be useful in the later development of practical atomic power plants for civilian use. Because of military necessity, we are years and decades ahead of where we would be under ordinary peacetime conditions. It is absolutely certain that no organization, the government included, would ever have spent over 6 billion dollars during the past 12 years in bringing our knowledge of atomic energy to the point where it is today.

WSE Elects Officers

The following members were elected to the Board of Direction of the Western Society of Engineers for 1953-54.

Charles E. DeLeuw.....President
John F. Sullivan, Jr..1st Vice President
Albert P. Boysen....2nd Vice President
Allan A. Bulley.....Treasurer
Clifford B. Cox....Trustee (one year)
George L. Jackson..Trustee (one year)
Bruce A. Gordon...Trustee (two years)
Charles L. Mee....Trustee (two years)
Robert S.

Hammond....Trustee (three years)
Hjalmar W.

Johnson.....Trustee (three years)
Alf Kolflat.....Trustee (three years)
Thomas M. Niles..Trustee (three years)
Gustav Egloff

....Washington Award Commission
O. G. Smith

....Washington Award Commission

Use Radioactivity in Gauging Coatings

Scientists are using radioactivity to measure tissue-paper-thin (0.0001 of an inch) coatings of silver on radar equipment with accuracy up to 10 millionths of an inch, it was disclosed at the National Electronics Conference at the Hotel Sherman in Chicago.

The development is the work of three physicists at Armour Research Foundation of Illinois Institute of Technology—Harold V. Watts, assistant physicist; C. A. Stone, associate physicist, and Leonard Reiffel, supervisor of nuclear physics.

Thin coatings of silver "insulate" brass radar waveguides ("pipelines" used to transmit radio waves). The trick is to maintain silver coatings of required thickness and uniformity.

Government standards call for microscopic examination of waveguide cross sections to determine plating thickness. The entire test, including preliminary cutting or stripping of waveguides, takes from three to four hours, and has the marked disadvantage of destroying the waveguide being tested.

Watts and his colleagues recommend bombardment of waveguides with radioactive radium-beryllium. Radioactive isotopes of silver are formed, and resulting radiation is measured by Geiger counters, affording a highly accurate picture of plating thickness.

The process takes about five minutes.

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Public Service Users to Get Gas Furnaces

The Public Service Company reported recently to the Illinois Commerce Commission that letters soon would be mailed out to approximately 25,000 customers authorizing them to install gas furnaces under the terms of the commission's gas restriction order.

The company said that the new authorizations would cover all individuals who had applied on or before March 20, 1952 for existing homes and on or before April 30, 1952 for new homes. Gas heat allocations are permitted only for single family dwellings and are based on the ratio of requests in each group according to date of application.

George R. Perrine, chairman of the commission, said that the additional gas heat authorizations at this time were made possible by cancellations from allocations made last year coupled with a small amount of additional gas which the company expects to receive this fall from expansion in pipeline flow capacity.

Gas heat previously had been authorized for all those who had applied up to December 31, 1951. The previous allocation followed completion of the new Texas Illinois natural gas pipeline from the gulf coast of Texas to Joliet from which Public Service received additional supplies of gas.

Applicants since March 20, 1952 for existing homes and since April 30, 1952 for new homes will remain on the company's gas heat waiting list under terms of the commission's restriction order. There will be approximately 65,000 on the waiting list after the present authorizations, the company reported.

The restriction order, in effect since July, 1946, must be continued, it was said, until further additional supplies of gas become available. This is dependent upon completion of the underground storage project now under construction near Herscher, Ill. by the pipeline companies which bring natural gas from Texas to the northern Illinois area. While the Herscher project may be completed by the end of this year, several months of trial operation will be required to assure complete reliability, it was said.

The project contemplates storage of gas during the summer months for withdrawal during the winter months.

New Circuits Give Savings

Prefabricated circuits promise great savings in the production of low power apparatus such as radio, television, hearing aids, automatic signals and other electronic devices. The new method has untold possibilities, Norman A. Skow, director of research and development of the Synthane Corporation, Oaks, Pa., told a meeting of The American Society of Mechanical Engineers in Columbus, Ohio, on April 28.

A printed circuit is a metal reproduction of a conductor pattern which has been bonded to an insulated material, Mr. Skow explained. Serving as a conducting medium in electronic assemblies, such circuits replace to a large extent the internal maze of wires normally found in conventionally assembled equipment.

Printed circuits have been achieved by plating metal patterns on plastic boards, by spraying metal into depressions in a plastic plate, by bonding rigid wiring harness to a plastic base, by fusing silver ink patterns on ceramics, or by etching of metal-clad plastics. The latter method is currently gaining in popularity and seems to be especially suited to mass production assembly procedures required in the highly competitive electronics industry.

Printed circuits are practical principally because of their simplicity and uniformity. They are particularly adaptable to very complex commutators and switching networks where sub-miniaturization is required. Elimination of manual wiring speeds assembly and, because mechanical reproduction reduces the probability of error, inspection time is automatically shortened while assem-

blies become more uniform and reliable, Mr. Skow said. Overhead is lowered because many more units may be produced in a given amount of factory space.

Materials Used

The electrical properties of printed circuits are largely determined by the base laminate, the metal foil and the adhesive used to bond the two. For most printed circuit applications, copper foil in a variety of thicknesses is bonded under heat and pressure to one or both sides of thermosetting laminated sheet stock of the desired grade and thickness.

Numerous experiments have been made to determine the suitability of copper, aluminum, brass and silver foils. Of these, copper has been the most widely used, but other metals are gaining popularity. Silver and brass possess excellent current-carrying characteristics, but suitable adhesives have not been developed which can produce a bond sufficiently strong for most service conditions. On the other hand, aluminum bonds well but poses a number of problems in soldering techniques. A partial solution to the soldering difficulty has been accomplished by using a thin layer of copper or tin alloyed to one surface of the aluminum foil.

Electrolytically produced copper foil is used, having one extremely smooth side while the other side is relatively rough. This smooth side permits uniformity of etching while the rough side becomes an ideal surface for bonding.

Any of the twenty-odd standard grades of thermosetting laminated products de-

(Continued on Page 20)

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(Continued from Page 19)

scribed in National Electrical Manufacturer's Association's "Standards for Laminated Thermosetting Products" will produce a satisfactory bond with copper.

Foil may be bonded to a laminate by one of two methods. Class 1 copper-clad laminate is produced from a predetermined number of resin-impregnated sheets to which is added a thin, dry sheet of adhesive film followed by a sheet of copper foil. The entire build-up is then subjected to heat (approximately 320°F) and high pressure (approximately 1000 lbs. per sq. inch) for about one hour. If desired, the adhesive film and foil may be added to both sides of the build-up.

Class 2 copper-clad laminate is designed to meet closer thickness tolerances than Class 1 material. It is produced by sanding a finished, cured sheet of laminate to the desired thickness, after which the adhesive and copper foil are added. It is then returned to the press for a second application of heat and pressure. Because of the additional work involved, Class 2 material is more expensive than Class 1.

After bonding, copper-clad sheets are usually sprayed with a strippable plastic film for protection against scratching, oxidation and scarring during subsequent trimming, packing and shipping operations.

Etching chemicals vary with the foil. For copper and brass, 38 to 40° Baume' ferric chloride solution is used; for aluminum, hydrochloric acid; for silver, 30% nitric acid. These solutions are normally used at 85 to 95°F.

Methods of assembly of printed circuits into finished electronic or electrical devices are as varied as the applications. The most obvious method is to simply punch or drill holes through the conductor and the laminate, inserting leads of standard components into the holes, and soldering the leads to the conductors. Complicated circuitry is normally laid out on both sides of the piece to provide for crossovers. Connections between conductors on opposite sides may be made by component leads, tinned eyelets, rivets, pins, or simply short lengths of wire. Using the proper laminate, components can be unsoldered and resoldered several times before foil shows a tendency to lift from the base, Mr. Skow said.

Use New Smoke Gauge

The smokescope, the latest instrument for estimating the density of smoke rising from stacks, was described before The American Society of Mechanical Engineers in Columbus, Ohio on April 28, by Nelson W. Hertz, who read a paper by a co-worker, John P. Strange, principal physicist of the Mine Safety Appliances Company, Pittsburgh, where the smokescope was developed.

Recent increased interest in the prevention of air pollution, resulting in smoke control laws in many cities, has stepped up the need to observe the density of smoke issuing from stacks. The new instrument, the speaker said, will eliminate the causes of error inherent in the methods used to date.

The estimation of smoke density is usually made by visual comparison of the smoke with shaded standards of a Ringleman chart which consists of squares of various shades of gray. The trouble with this method, it was pointed out, is that the observer must take into account variations in lighting and background against which the smoke is viewed, as well as the illumination of the chart.

One instrument devised to improve the reproductibility of smoke observations is the Umbrascope, a small tube through which the smoke can be viewed and compared with a standard smoked glass.

Another method, devised by Harry C. Ballman, Smoke Regulation Engineer of the City of Columbus, uses two frames of photographic film darkened to standard smoke density and mounted with a section of clear glass between them. The

comparator is held to the eye; the smoke is viewed through the clear section and simultaneously compared with the darkened film. Estimations made in this manner may be erroneous because the observer must refocus his eye in looking from the stack to the film.

How the Smokescope Works

In the smokescope, to eliminate the effect of differences in lighting, a reference standard film disk is viewed against the background adjacent to the stack. In this manner the smoke and the reference film receive light from the same source. Smoke density estimations are therefore unaffected by background variations or by the brightness of the day.

To further improve the accuracy with which smoke density estimations can be made, a lens is used to project a virtual image of the reference standard to a focal distance equivalent to that of the stack. This makes it unnecessary to refocus the eye while making a comparison.

In the smokescope the stack is viewed through three aligned apertures in a closed, tubelike section. These apertures limit the field of vision to the area of the stack and prevent entrance of stray light. The aperture nearest the eye is the unsilvered center spot of a mirror. On the remainder of this mirror is reflected, by means of a mirror and lens, an image of the film showing the shades for various densities of smoke. Thus, the eye sees the smoke from the stack in the center surrounded by the reference film for comparison, without needing to change focus, the paper said.

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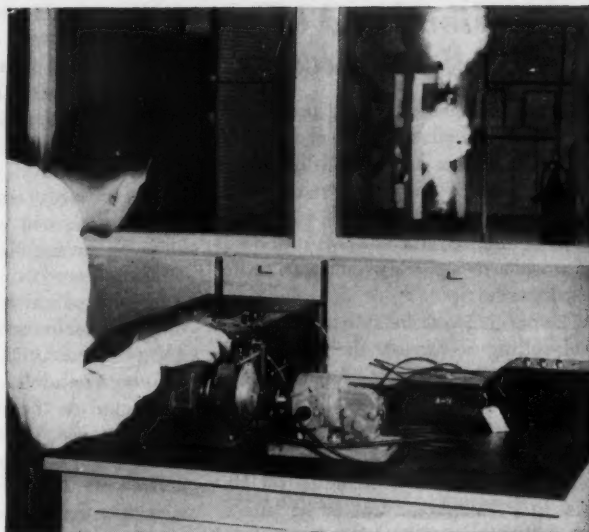
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Television Now Used to Speed Production

Television is the newest production wrinkle at United States Steel Corporation's Gary Sheet and Tin Mill where a camera, monitor and receiver have been installed on the 80-inch hot strip mill, it was announced May 1. This mill holds the world's record for production of hot rolled steel strip.

The public won't be able to tune in on steel rolling scenes on their home TV sets, and the mill operators can't switch to the ball game on industrial TV. The steel mill television program will be strictly steel production.

The TV installations made by the Illinois Bell Telephone Company, enable the mill operator to keep watch and check the condition of the fiery red steel strip as it leaves the last finishing stand and speeds a distance of 395 feet—an average city block—to the coilers. The extra eyes of TV help the operator to spot potential trouble and take corrective action before the strip is coiled.

The camera is mounted 48 feet above

the run-out table leading to the coilers. It commands an overall view of the strip from the finishing stand to coiler. A monitor with a 10-inch screen is mounted on the north wall of the mill opposite the No. 1 coiler. It is used for adjustment only.

The TV set, comparable to the home type, is mounted on the control pulpit adjacent to the No. 10 finishing stand. The operator can ignore a series of water-sprays which obscures his view of the steel strip and concentrate on his TV receiver. On his 10-inch screen of 525 horizontal lines he can keep constant vigil on the strip.

To provide sufficient light for the television camera, the mill is lighted up like a Hollywood studio. Engineers have installed a bank of forty-four 500-watt spotlights on 4-foot centers directly above the run-out table on which the steel strip travels to the coilers.

Chief advantage of television to the 80-inch hot strip mill is the opportunity it affords to keep a constant watch and spot potential trouble, such as cobbles and pile ups, in time to make necessary corrections.

Letters from Leaders on Engineer Training

In the last issue of *Midwest Engineer* we published the first of about thirty letters received from leaders of Chicago-area firms concerning shortcomings noted in the engineers in their employ. Many of the letters also suggested what the engineers should do to correct their deficiencies.

Significantly, the engineer's technical training is generally considered adequate. In the broad area of Human Relations, however, engineers seem often to be "under achievers," according to the viewpoint of the industrial leaders as reflected in their letters.

We are printing another of these letters in this issue, as we shall do in future issues. Although the letters may be of greatest value to the younger engineers, we hope that all of the engineers who read them will benefit.

Here, then, is the next letter:

Dear Mr. Becker:

The following is in response to your letter of August 31, 1951, requesting our views as to the educational needs of young engineers so that they may qualify themselves to be supervisors in engineering work and ultimately to advance into executive positions.

Our young engineers seem to be adequately versed in the technical subjects but could greatly benefit by acquiring certain additional qualifications. The first, and probably most serious, need is ability to express themselves clearly and concisely, both verbally and in writing reports; many lack the talent of explaining technical features to a layman. There is also need for engineers to develop the habit of looking at a problem or project from an over-all viewpoint so that in working out the details all angles of the project may be covered. In this way, by adequate organization of all elements of a study, the importance of following through on all details can be recognized. It has been our experience that some engineers have a tendency to neglect seemingly minor details which may become

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major obstacles at the time of construction.

As bosses, the young engineers are continuously involved in maintaining satisfactory human relations with the people they supervise. There is need here for acquiring humility as to the limitations of straight technical training, of developing warm human sympathies, the exercise of which calls for great skill in applying tact and recognizing the other man's point of view.

From the above, it appears that in our judgment an increase in technical proficiency is needed mainly in the field of report writing. The other requirements that should be added to the stature of an engineer appear to be those needed and useful in any business endeavor.

Dr. Rossini Lectures at A. S. T. M. Meeting

Dr. Frederick D. Rossini, Silliman Professor and Head of the Department of Chemistry and Director of the American Petroleum Institute Research Laboratory at the Carnegie Institute of Technology, will present the 27th Edgar Marburg Lecture on the subject "An Excursion in Petroleum Chemistry."

This lecture, given at the annual meetings of the American Society for Testing Materials, originated as a testimonial to the first Secretary of the Society and was established to emphasize the importance of furthering knowledge of properties and tests of engineering materials.

The 1953 ASTM Annual Meeting will be held in Atlantic City during the period June 29 through July 3 and on Wednesday afternoon, July 1, Dr. Rossini will deliver the Edgar Marburg Lecture. He will describe outstanding developments in our knowledge of petroleum. Dr. Rossini will outline the interesting story of fundamental research in petroleum chemistry as performed in the laboratories of petroleum companies.

He will discuss projects supported cooperatively by the petroleum industry through the American Petroleum Institute, and in particular will review API Research Projects covering the composition of crude petroleum and the researches conducted in order to make available to the laboratories of the petroleum industry in particular, and to the technical world in general, all of the known data on hydrocarbons and related compounds. This extensive laboratory work also involved searching the entire scientific literature field, appraising and arranging data in a useful form and distributing this data both on a national and international scale.

Dr. Rossini has achieved renown as an authority in the field of physical chemistry. He has a broad background as an educator, lecturer, scientist and author, and years of service as a leading member of ASTM Committee D-2 on Petroleum Products. Dr. Rossini has a deep personal interest in teaching and has lectured at leading universities throughout the country. In 1946, Dr. Rossini was elected President of the Commission on Thermochemistry of the International Union of Pure and Applied Chemistry, having been nominated in 1934 as the United States member of the Commission. He is the author or co-author of approximately 150 scientific papers dealing with thermochemistry and hydrocarbons.

To Conduct Course on Statistical Control

The College of Engineering at the University of Colorado at Boulder will conduct an intensive training course in Statistical Quality Control from June 16-26, 1953.

John F. Wagner, Assistant Professor of Applied Mathematics, who will be in charge of the course, says that because we are continually faced with mass-production problems in both civilian and defense goods, the control of quality of the product has become an increasingly important management concern.

Instructors for the course will be E. L. Grant, of Stanford University, author of *Statistical Quality Control*, L. A. Knowler, of Iowa University, and M. E. Wescott of Rutgers University, editor of *Industrial Quality Control*. In addition, men from industry will discuss their experiences in applying these principles.

Wagner said that the course is most useful if men who are acquainted with the overall production and inspection operations of a particular company are trained in these techniques.

Application or further information about the course can be obtained by writing John F. Wagner, 214 Ketchum, University of Colorado, Boulder, Colorado.

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Reviews of Technical Books

Foundation Engineering

Foundation Engineering by R. B. Peck, W. E. Hanson and T. H. Thornburn; John Wiley and Sons, Inc., New York 16, N. Y. 1953. 410 pages. \$6.75.

This is an elementary but exceptionally well organized treatment of the subject of Foundation Engineering.

In the writer's opinion the text is unique among books on Foundation Engineering in that it is based on an up-to-date knowledge of Soil Mechanics. In fact the first five chapters are devoted exclusively to a brief but concise treatment of Soil Mechanics as it is related to Foundation Engineering. The specialist in Soil Mechanics and Foundation Engineering will find little that he is not already familiar with, but the practicing structural engineer as well as the student should find it an excellent guide in the study and design of the commonest types of building foundations.

E.V.

Statistics

An Introduction to Statistics, by Charles E. Clark; John Wiley and Sons, Inc., New York 16, N. Y. 1953, 266 pages. Price \$4.25.

The book approaches statistics from an essentially modern point of view, the emphasis being on the analytical rather than the descriptive aspects of the subject. Matters such as graphical presentation, curve fitting, and time series analysis are omitted; on the other hand, a substantial amount of material on statistical inference is included. Moreover, the probability basis of statistics is introduced at the outset and stressed throughout. The book will therefore have an especial appeal to engineers and other scientific workers, who will find it a good elementary introduction to many of the basic ideas of statistical inference they are likely to require in their own work or encounter in the literature in their field of interest.

A chapter is devoted to each of the following: permutations and combinations; probabilities; frequency and probability distributions; reliability of sample means and probabilities; significance of the difference between two sample means of percentages; analysis of variance; inferences from Chi-square; and correlation. The author keeps in mind the problem of the student whose mathematical equipment falls short of a mastery of college algebra. Difficult derivations are omitted, and the theorems are simply and clearly stated, care being taken to distinguish between those containing exact and those containing approximate statements. An unusual feature, especially useful if one is studying without benefit of instruction, is the 34 pages of answers to problems,

often including the method of solution and a discussion as well as the numerical answer.

J. M. E.

Differential Equations

Numerical Solutions of Differential Equations, by William E. Milne, John Wiley and Sons, Inc., New York 16, N. Y. First Edition, 1953. 275 pages. Price \$6.50.

This book is in the Wiley Applied Mathematics Series, which is edited by I. S. Sokolnikoff. The Applied Mathematics Series is devoted to books dealing with mathematical theories underlying physical and biological sciences, and with advanced mathematical techniques needed for solving problems of these sciences.

During the decade just passed there has been much interest and activity in the field of numerical methods in general, and the numerical solution of differential equations in particular. At the same time, progress in mechanical computation has opened up areas heretofore deemed inaccessible.

This book attempts to acquaint the reader with some of the more important techniques available for the numerical solution of ordinary and partial differential equations. More specifically, the book consists of a thorough exposition of the substitution of a finite difference algorithm for the differential equation proper. The magnitudes of the errors and means of their reduction are an important part of the exposition. Less systematic methods of recent origin, such as relaxation, are also discussed.

A very extensive bibliography of books and articles dealing with the topics of this text is given at the end of the book.

H.R.

Sewage Treatment

Sewerage and Sewage Treatment by Harold E. Babbitt, John Wiley & Sons, Inc., New York 16, N. Y. Seventh Edition, 1953. 674 pages. \$8.00.

This new edition of a much-used text should meet with general approval. Its content has been extended and considerably revised. This is probably the most up-to-date text in the field.

The author has presented additional information on open-channel flow, and explains that actual flow conditions in conduits are different from that commonly assumed. Recent treatment methods are thoroughly covered and special treatment problems discussed.

Throughout the text an effort has been made to offer a practical approach for those concerned with planning, design and operation of sewerage systems.

J.G.D., W.S.E.

WSE Personals

J. Harris Ward, Vice President of Commonwealth Edison Company, has been placed in charge of all commercial and sales activities of the Edison system, including the Public Service Company Division, it is announced by Willis Gale, Chairman. In taking over his new duties, Mr. Ward will relinquish the position of Treasurer.

Murray Joslin, heretofore Assistant to the Chairman, has been elected a Vice President and will be in charge of the activities previously under Mr. Ward's supervision.

D. Robert Bower, formerly Assistant Vice President, has been elected Edison's Treasurer.

Royal G. Bigelow, retiring professor of industrial engineering at Northwestern University's Technological Institute, was honored May 8 at the annual Engineering Alumni dinner in Sargent hall, Evanston campus. Institute alumni and faculty members and their wives were invited to attend.

Bigelow, who has taught at Northwestern for 33 years, will retire at the end of the current academic quarter. He has served as associate professor of industrial engineering since 1939. He is a member of Pi Tau Sigma and the American Society of Engineering Education, besides the Western Society. He lives at 2644 Lawndale avenue in Evanston.

Kenneth Brunner has resigned from the position of Associate Highway Engineer with the California State Division of Highways to accept the position of Chief Design Engineer with the firm of Francis H. Bulot, Consulting Engineers, of Los Angeles. In 1948, Mr. Brunner received his B.S. degree in Civil Engineering from the Northwestern Technological Institute. He is a Junior Member of the American Society of Civil Engineers, and is a Registered Civil Engineer in the State of California.

Frank J. Foley and Richard C. Lindberg have announced the formation of the firm of Foley and Lindberg, organized for the practice of the law of patents, trademarks, copyrights and unfair competition, with offices at 209 South LaSalle Street, Chicago 4, Illinois. The telephone is Financial 6-2853.

Louis C. Gabbard, formerly Construction Estimate and Expense Control Engineer, Chicago area, Illinois Bell Telephone Company, was transferred, effective April 1, to the General Personnel Department as Personnel Supervisor.

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Crerar Library News and Notes

"A Technical Library Must Grow or Cease to Be Useful," is the sub-title of a flier printed by the Library to spotlight the need for more funds to purchase technical publications. The number of such publications has increased enormously in recent decades, and in spite of an increase of almost 100% in expenditures for new books and periodicals in the past six years, there is still need for increasing funds. The two broad fields which are strongly supported by gifts are chemistry and medicine. The other sciences and engineering must depend on endowment income and company memberships. Assistance from engineers in the search for special funds for physics, mathematics and all branches of engineering would be welcomed by the Library.

* * *

The major objective of Crerar during the past five years has been a complete review of the Library's program—collections, services and use of space. An intensive review of acquisitions policy has led to a published statement of policy, copies of which may be had on request to the Librarian. Space review has resulted in much more efficient use of space for library purposes and con-

sequent increased space for rent to scientific organizations. In the area of service, numerous minor improvements have been accomplished, but the only major developments have been in Research Information Service and Photoduplication Service, both of which are non-profit fee services.

The Library is now engaged in a general survey of its financial program. It is hoped that ways and means will be found not only to maintain the present level of collections and services, but to greatly improve general services to the Library's "public," namely students and professional men and women in science, medicine and engineering. There are many services which would be welcomed by technical personnel using the Library, which cannot be given by the present limited staff.

Electrical World Volumes Are Available to Members

Nineteen volumes of The Electrical World from 1894 to 1904 are available to whomever would care for them. The owner must dispose of them because his property lies in the path of the Northwest Highway which will run along there. Anyone interested in these volumes should contact the Headquarters of the Western Society.

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OVER THE MANAGER'S DESK

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R-9794 TOOL ENGINEER. Grad. M. E. Age: 30-40. 10 years exp. in machine shop and tool room operations. Knowledge of metal fabrication and punch press. Duties: methods and tooling for job lot production for metal fabrication company. Salary: \$8000-\$10,000. Employer will negotiate fee. Location: Chicago area.

R-9793 CONCRETE RESEARCH C.E. Age: up to 35. 1 plus years exp. in concrete making or research work. Duties: work on highway development problems regarding use of concrete pavement and studying resurfacing with concrete. Salary: up to \$450 per mo. Employer will pay 1/2 fee. Some Travel.

R-9792 DESIGN AND DEVELOPMENT, ME. Age: 35-50. 7 plus years exp. in design and development of high speed machinery. Knowledge of printing presses helpful. Duties: redesigning and refining present line of printing presses for newspapers and magazines. For a Manufacturer. Salary: \$8000-\$12,000 per year. Employer will pay fee. Loc.: Chgo.

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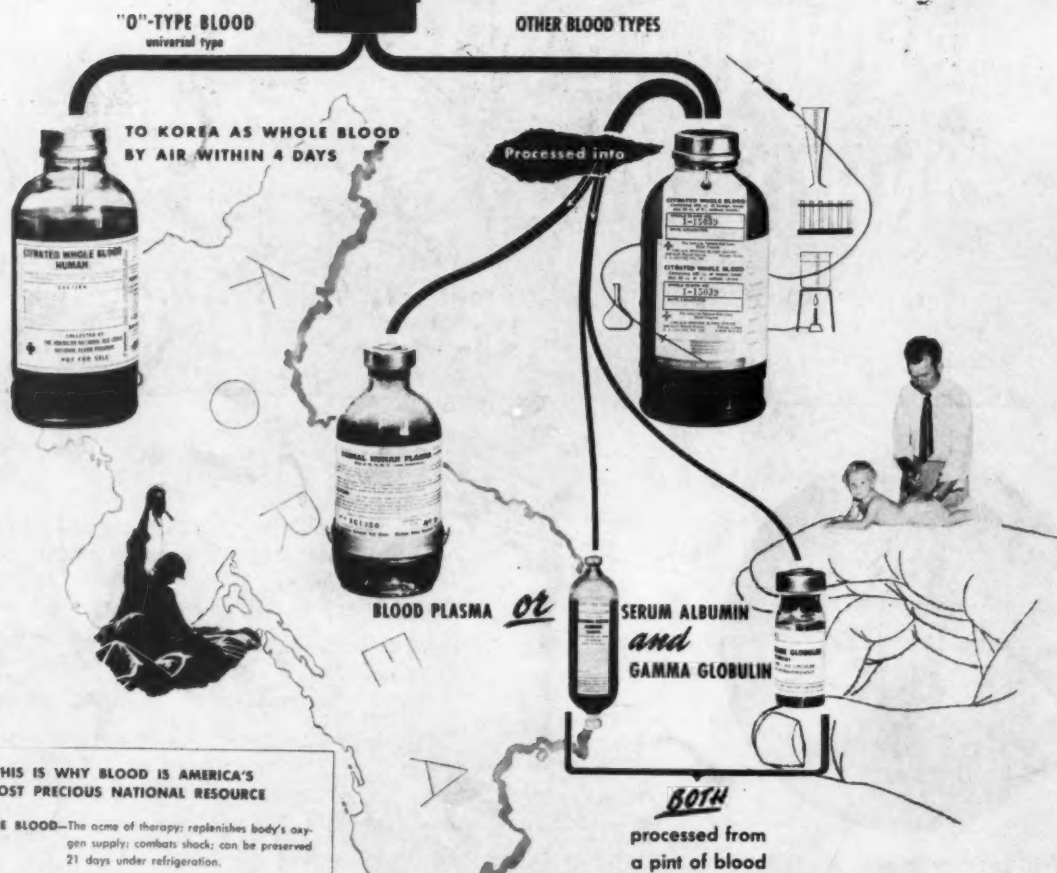
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